Silicon holds enormous potential for the implementation of a spin-based quantum computer, due to its zero nuclear spin [1] and low spin-orbit coupling [2] in silicon-28 isotopes. Recently, silicon-28 enriched Silicon Metal Oxide Semiconductor (Si-MOS) devices have been used to demonstrate both two qubit logic gates [3] and one qubit gates with high control fidelity [4]. These utilise Electron Spin Resonance (ESR), a technique that can control spin qubits using an oscillating magnetic field generated via a microwave stripline.

The electrical control of single spin qubits [5, 6] based on semiconductor quantum dots provides an alternative approach for scalable quantum computing, due to the fact that electric fields can be produced easily and can be more spatially focused than magnetic fields. By incorporating a permanent magnet, the qubits can be driven via an oscillating electric field, via a method called Electric Dipole Spin Resonance (EDSR). Here we present a number of design considerations and simulations on a microwave coplanar waveguide for Si-MOS quantum devices. At 1mW input, a Rabi frequency of 10MHz is generated by EDSR with minimal noise.

By applying the concept of a multiplexer [7], Si-MOS quantum devices can overcome the obstacle of the limited number of signal wires available in low-temperature measurement probes, thus enabling the testing of multiple devices in a single thermal cycle. We outline the design and fabrication procedure for a multiplexer (MUX) which can operate up to 8 Si-MOS quantum devices. The MUX consists of 6 control gates and up to 16 analog signal I/Os. 30 variations of the MUXs were fabricated in order to determine the optimal physical device dimensions for optimal performance.

References

Inverse spin Hall Effect in lanthanum strontium manganite/platinum bilayers

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Since the conventional charge-based electronics has reached a bottleneck for further reduction of device size due to the fatal issues such as thermal fluctuation-induced noises and energy loss by Joule heating, the search for alternative technologies to solve these problems leads naturally to the usage of spin. Charge and spin are two intrinsic parameters of an electron. Two advantages of using spins to carry data information are the fast read-and-write speed and the less energy loss. Among many, the integrated mechanism of generation, manipulation, and detection of spin current has become the most urgent knowledge for the realization of spintronics memory devices.

Ferromagnetic resonance (FMR) driven spin pumping is a novel method to generate the spin angular momentum from the ferromagnetic (FM) layer and transfer it into the adjacent normal metal (NM) layer in an FM/NM bilayer system. Consequently, the spin current can be probed in the NM layer via inverse spin Hall Effect (ISHE) when spin-charge conversion occurs. Among many, Pt is considered as the most effective NM for spin-charge conversion due to its strong spin orbital coupling [1]. A scaling behavior of the spin pumping effect observed in various FM/Pt bilayer systems prompts us to study the existing intrinsic parameters to control spin current [2]. In this report, we focus on the rare discussed system La$_{0.7}$Sr$_{0.3}$MnO$_3$(LSMO)/Py bilayer and investigate its Inverse spin Hall effect [3,4]. By fitting with the spin pumping model, the values of several spin transport parameters could be obtained, such as spin mixing conductance, spin diffusion length and spin Hall angle. The comparison of our findings with previous reports provides some insight to resolve the controversy of experimental results from different groups. In addition, the spin transport characterization of our sample system reveals that the half-metallic LSMO can generate comparable spin current density with that of Py/Pt via the spin pumping mechanism.

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References
We have developed a novel free-liquid jet sample environment with a Y-shaped micromixer for turbulent flow to make the very early stages of nucleation and growth of fast forming quantum dots like CdS in liquid media experimentally accessible [1].

Key advantages of this device compared to conventionally capillary based stopped-flow cells are:
1) Access to a so far unexplored early time regime down to 20 µs (1000 times faster than usually available),
2) High time resolution (as short as 10 µs),
3) Reaction time is chosen by jet velocity and the position of probe along the jet,
4) Decoupling of chemical reaction time and measurement time (data of high quality),
4) Missing friction between liquid and container wall (well defined chemical reaction time),
5) No radiation damage in the sample (intrinsic reaction process), and
6) No scattering from container walls (data of high quality).

With synchrotron X-ray scattering as a probe we have measured the formation and growth of quantum dots in aqueous solution and report here on CdS as a prototype example [2, 3].

SAXS data show a non-classical two-step pathway with a surprising stability of a structurally relaxed cluster with a diameter of 2.5 nm. This relaxation together with a likely interface restructuring [4] is at the origin of an energy barrier which makes an agglomeration into larger units a slow process. Ab initio theoretical calculations support the amorphous-like nature of the primary clusters and further reveal quantitatively an activation energy of about 0.4 eV for cluster attachment (see Fig 1). WAXS data confirm, that the particles at this early stage are not yet crystalline.

References

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While known for more than a century, ionic liquids – commonly defined as salts with a melting point around or below room temperature – have only become a staple in material research over the course of the last quindecennial. It is their unique properties, including a large electrochemical window and negligible vapor pressure, that makes these substances particularly interesting for the development of novel applications including, among others, catalysis, lubrication and, most notably, electrochemistry.

While downsizing technology in an attempt to build smaller, yet more powerful devices, interface effects start to become more and more dominant in these systems and a sound understanding of occurring structural phenomena is a prerequisite for engineering applications.

Using an unprecedented complementary approach, combining experimental X-ray scattering data (Fig 1, left panel) and atomistic simulation (Fig 1, right panel), we study the behaviour of an archetypical family of protic ionic liquids, dialkylimidiazolium–bis(trifluormethylsulfonyl)imide ([CnMIm][NTf2]), at the sapphire (001)–liquid interface. X-ray reflectivity (XRR) allows us to reveal an interface-normal layering profile of the buried solid–ionic liquid interface. We report a strong excess of cations at the interface, followed by alternating anion/cation layers, slowly decaying towards the bulk over a region of about 40 Å. Moreover, the experimental data can be employed to parametrize and verify force fields used in our molecular dynamics simulations (MD). Reaching a good agreement between XRR and MD puts us in a position to extract reliable information on an atomic level that is otherwise inaccessible by the experiment alone. We find that both cations and anions in the vicinity of the substrate tend to assume a very specific orientation/conformation, enabling them to efficiently form hydrogen bonding with the substrate. The anions remaining close to the interface take a well-defined lateral order, intercalating the network of cations.

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Figure 1: Experimental reflectivity with fitted data (left panel) and deduced layering near the sapphire interface from fit of XRR data and MD simulations (middle panel). The right panel shows the molecules in the simulation box.
Metal to insulator boundary of expanded f.c.c. C_{60} superconductors

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A new superconductor Cs_{x}C_{60} was discovered in 2008\textsuperscript{[1]}. The superconducting critical temperature (T_{C}) reaches 38K under pressure and it broke the record of T_{C} in A_{x}C_{60} (A = alkali metal) families (Fig.1). Intriguingly, unlike the previously reported fulleride superconductors like K_{x}C_{60} or Rb_{x}C_{60}, T_{C} decreases as lattice parameter is increased after achieving the maximum T_{C} in Cs_{x}C_{60}. Emergence of the $T_{C}$-lobe on phase diagram indicates that fulleride superconductors cannot simply be explained by BCS theory [2-4]. It was revealed that Cs_{x}C_{60} is Mott insulator under ambient pressure. Hence, there is strong electron correlation in expanded lattice region. Electrical transport properties are expected for understanding the electronic state. However, electrical transport measurements have not been accomplished systematically because of some experimental difficulties. Alkali metals are so air sensitive that special treatments are necessary during experiments. Moreover, it is very difficult to prepare a single crystal or thin film of ternary fulleride, for example Rb_{x}Cs_{y}C_{60}. We focused on making powder pellet of fulleride, because there is no difficulty in synthesizing a high quality sample regardless of whether it is binary or ternary fulleride. We succeeded in measuring the intrinsic resistivity by employing a pressure cell with pressure medium. The resistivity was measured with varying temperature and pressure. Pressure was controlled physically and chemically by using a pressure cell and by changing the molar ration of alkali metal, respectively. Expanded fulleride shows semiconductor-like behaviour around room temperature. As temperature is decreased, the resistivity turns down into metallic phase and finally drops zero which corresponds to superconductivity. Critical temperature and volume relationship of our samples was shown in Fig.2. $T_{C}$-lobe was obtained in the electrical transport measurement as well as the magnetic susceptibility measurement. The boundary of metal insulator transition or crossover point was different from that obtained from magnetic measurement.

References
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